2 Overview of Wetlands, Riparian Areas, and Vegetated Treatment Systems

Understanding the role of wetlands, riparian areas, and vegetated treatment systems in abating NPS pollution requires an understanding of several terms. Because federal, state, and local laws, ordinances, and policy documents define these terms in a number of different ways, this chapter provides an overview of how the terms might be interpreted and defines the terms as they are used in this document.

2.1 Wetlands and Riparian Areas

For purposes of this guidance, ***wetlands*** are defined as

> *those areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.*

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As waters of the United States, wetlands are afforded protection under the Clean Water Act. Although the focus of this document is on the function of wetlands in reducing NPS pollution, it is important to keep in mind that wetlands are ecological systems that perform a range of functions (e.g., hydrologic, flood control, and aquatic habitat functions) in addition to pollutant removal. Therefore, adverse impacts on existing wetlands should be avoided to the maximum extent possible.

Definitions of wetlands are also contained in federal, state, and local laws, ordinances, and policy documents. Because those definitions do not always use scientific concepts, they might differ between states or even between localities within a state.

For purposes of this guidance, ***riparian areas*** are defined as

> *A vegetated ecosystems along a water body through which energy, materials, and water pass. Riparian areas characteristically have a high water table and are subject to periodic flooding and influence from the adjacent water body. These systems encompass wetlands, uplands, or some combination of these two landforms. They will not in all cases have all the characteristics necessary for them to be also classified as wetlands.*

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Like the definitions for wetlands, the definitions for riparian areas can vary. For example, a definition of riparian areas might be based on geographic region (arid or humid climates) or on distance from a stream channel rather than on site characteristics.

Figure 2-1 illustrates the general relationship between wetlands, uplands, riparian areas, and a stream channel. Identifying the exact boundaries of wetlands or riparian areas is less critical than identifying ecological systems of concern. For instance, even those riparian areas that fall outside wetland boundaries provide many of the same important water quality functions that wetlands provide. In many cases, the area of concern might include an upland buffer adjacent to sensitive wetlands or riparian areas that protects them from excessive NPS impacts or pretreats inflowing surface waters.

Wetlands and riparian areas can play a critical role in reducing NPS pollution by intercepting surface runoff, subsurface flow, and certain groundwater flows. Their role in water quality improvement includes processing, removing, transforming, and storing such pollutants as sediment, nitrogen, phosphorus, and certain heavy metals (Washington State Department of Ecology, 1996). Research also shows that riparian areas function to control the release of herbicides into surface waters. Thus, wetlands and riparian areas buffer receiving waters from the effects of pollutants or they prevent the entry of pollutants into receiving waters. It is important to consider that degradation of wetlands and riparian areas can inhibit their ability to treat NPS pollution. Degraded wetlands and riparian areas can also become sources of NPS pollution.

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The functions of wetlands and riparian areas include water quality improvement; stream shading; flood attenuation; shoreline stabilization; groundwater exchange; and habitat for aquatic, semiaquatic, terrestrial, migratory, and rare species. Wetlands and riparian areas typically occur as natural buffers between uplands and adjacent water bodies. Loss of these systems allows for a more direct contribution of NPS pollutants to receiving waters. The pollutant removal functions associated with wetlands and riparian area vegetation and soils combine the physical process of filtering and the biological processes of nutrient uptake and denitrification (Lowrance et al., 1983; Peterjohn and Correll, 1984). Riparian forests, for example, have been found to contribute to the quality of aquatic habitat by providing cover, bank stability, and a source of organic carbon for microbial processes like denitrification (James et al., 1990; Pinay and Decamps, 1988). Riparian systems, particularly in western regions, have been shown to stabilize the recharge of shallow aquifers in a manner that supports streamflows of longer natural duration (Platts and Jenson, 1990). Riparian forests have also been found to be effective at reducing in-stream pollution during flood flows (Karr and Gorman, 1975; Kleiss et al., 1989).

In highly developed urban areas, wetlands and riparian areas can be virtually destroyed by construction, filling, channelization, or other significant alterations. In agricultural areas, wetlands and riparian areas can be affected by overuse of the area for grazing or removal of native vegetation and replacement with annual crops or perennial cover. In addition, significant hydrologic alterations might have occurred to expedite drainage of farmland. Other significant impacts might occur as a result of various activities such as highway construction, surface mining, deposition of dredged material, and excavation of ports and marinas. All these activities have the potential to degrade or destroy the water quality improvement functions of wetlands and riparian areas and might exacerbate NPS pollution problems.

A wetland's position in the landscape affects its water quality functions. Some cases have been studied sufficiently to predict how an individual wetland will affect water quality on a landscape scale (Whigham et al., 1988). For example, relationships have been demonstrated between the extent of individual wetlands and lowered suspended solids, fecal coliform, and nutrients in streams (Detenbeck et al., 1993; Johnson et al., 1990). Also, wetlands that border first-order streams were found by Whigham and others (1988) to be efficient at removing nitrate from groundwater and sediment from surface waters. When located downstream from first-order streams, wetlands and riparian areas were found to be less effective than those located upstream at removing sediment and nutrient from the stream itself because of a smaller percentage of stream water coming into contact with the wetlands (Whigham et al., 1988). It has also been estimated that the portion of a wetland or riparian area immediately below the source of NPS pollution might be the most efficeint at removing pollutants (Cooper et al., 1987; Lowrance et al., 1983; Phillips, 1989).

Although wetlands and riparian areas reduce NPS pollution, they do so within a definite range of operational conditions and cannot be viewed as a treatment mechanism for unlimited amounts of NPS pollution. When hydrologic changes or NPS pollutants exceed the natural assimilative capacity of wetlands and riparian areas, these systems become stressed and can be degraded or destroyed. A degraded wetland has less ability to remove NPS pollutants and to attenuate storm water peak flows (Bedford and Preston, 1988; Richardson and Davis, 1987; Richardson, 1988). In addition, a degraded wetland can deliver increased amounts of sediment, nutrients, and other pollutants to the adjoining water body, thereby acting as a source of NPS pollution instead of a treatment (Brinson, 1988; Richardson, 1988). Therefore, wetlands and riparian areas should be protected to the maximum extent possible from changes that would degrade their existing pollution abatement functions. This protection can be accomplished by applying NPS management measures appropriate to the source of pollutants (e.g., activities associated with agriculture, urban development, forestry, hydromodification, and marinas and recreational boating). Finally, degraded wetlands and riparian areas should be restored, where possible, to serve an NPS pollution abatement function.

2.2 Vegetated Treatment Systems

The term *vegetated buffer* is currently used in many contexts, and there is no agreement on any single concept of what constitutes a buffer, what activities are acceptable in a buffer zone, or what is an appropriate buffer width. In one usage, the term vegetated buffer refers to natural riparian areas that are set aside or restored to filter pollutants from runoff and to maintain the ecological integrity of the water body and the land adjacent to it (Nieswand et al., 1989). In another usage, the term refers to constructed strips of vegetation used in various settings to remove pollutants in runoff from a developed site (Nieswand et al., 1989). Finally, the term vegetated buffer can be used to describe a transition zone between an urbanized area and a naturally occurring riparian forest (Faber et al., 1989). In all these contexts, buffers can provide value to wildlife, as well as aesthetic value.

A vegetated buffer usually has a rough surface and typically contains a heterogeneous mix of ground cover, including herbaceous and woody species of vegetation (Stewardship Incentive Program, 1991; Swift, 1986). This mix of vegetation allows the buffer to function like a filter for pollutants. A vegetated filter strip can also be constructed to remove pollutants in runoff from a developed site, but a filter strip differs from a vegetated buffer in that a filter strip typically has a smooth surface with a vegetated cover made up of a homogeneous species of vegetation (Dillaha et al., 1989a).

For the purpose of this guidance, *vegetated buffers* are defined as

> *strips of vegetation separating a water body from a land use that could act as a nonpoint pollution source. Vegetated buffers (or simply buffers) are variable in width and can range in function from a vegetated filter strip to a wetland or riparian area.*

Vegetated buffers are defined as strips of vegetation separating a water body from a land use that could act as a NPS pollution source.

To avoid confusion, the term vegetated buffer is not used in this document. Instead, this guidance focuses specifically on the role of wetlands, riparian areas, and vegetated treatment systems in abating NPS pollution.

For purposes of this guidance, vegetated treatment systems (VTS) are defined to include vegetated filter strips or constructed wetlands or a combination of both. Both of these systems have been defined in scientific literature and have been studied individually to determine their effectiveness in NPS pollutant removal.

In this guidance, *vegetated filter strips* (VFS) are defined as (Dillaha et al., 1989a)

> *created areas of vegetation designed to remove sediment and other pollutants from surface water runoff by filtration, deposition, infiltration, adsorption, absorption, decomposition, and volatilization. A vegetated filter strip is an area that maintains soil aeration as opposed to a wetland, which at times exhibits anaerobic soil conditions.*

In this guidance, *constructed wetlands* are defined as (USEPA, 1998a)

> *wetlands that use natural processes involving wetland vegetation, soils, and their associated microbial assemblages to assist, at least partially, in treating an effluent or other source water. These systems are engineered and constructed in uplands, outside 'waters of the United States,' unless the water source can serve a significant restoration function to a degraded system.*

In areas where naturally occurring wetlands or riparian areas do not exist or cannot be restored to original sites, VTS can be designed and constructed to perform some of the same functions. When such engineered systems are installed for a specific NPS pollution abatement purpose, however, they might not offer the same range of functions that naturally occurring wetlands or riparian areas offer. Vegetated treatment systems have been installed in a wide range of settings, including cropland, pastureland, forests, cities, and urbanizing areas, where the systems can perform a complementary function of sediment control and surface water runoff management. Vegetated treatment systems should be considered to have wide-ranging applicability to various NPS categories.

Vegetated filter strips are defined as created areas of vegetation designed to remove sediment and other pollutants from surface water runoff by filtration, deposition, infiltration, adsorption, absorption, decomposition, and volatilization.

When properly installed and maintained, VFS have been shown to effectively prevent the entry of sediment, sediment-bound pollutants, and nutrients into water bodies. Vegetated filter strips reduce NPS pollutants primarily by filtering water passing over or through the strips. Properly designed and maintained VFS can substantially reduce the delivery of sediment and some nutrients to waters from nonpoint sources. With proper planning and maintenance, VFS can be a beneficial part of a network of NPS pollution control measures for a particular site. Efficiencies of VFS and riparian areas in removing sediments and nutrients from water passing over and through the systems are discussed later in this document. VFS are often coupled with practices that reduce nutrient inputs, minimize soil erosion, or collect runoff. Where wildlife needs are factored into the design, VFS or buffers in urban areas can add to the species diversity of the urban environment by providing wildlife nesting and feeding sites, in addition to serving as a pollution control measure. However, VFS might require maintenance such as grass mowing or removal of accumulated sediment. These and other maintenance activities might preclude some of their value for wildlife, for example, by disturbing or destroying nesting sites.

Constructed wetlands are designed to mimic the pollutant-removal functions of natural wetlands and might lack aquatic habitat functions and species diversity. It is important to note that aquatic plants and benthic organisms used in constructed wetlands serve primarily to remove pollutants. Constructed wetlands may or may not be designed to provide flood storage, groundwater exchange, or other functions associated with natural wetlands. In fact, if there is a potential for exposing wildlife to contamination or other detrimental impacts, constructed wetlands should be designed to discourage use by wildlife. If constructed wetlands are planned and designed correctly, however, they can be designed to provide significant wildlife habitat, water reuse, and public use opportunities.

Constructed wetlands are defined as wetlands that use natural processes involving wetland vegetation, soils, and their associated microbial assemblages to assist, at least partially, in treating an effluent or other source water.

Pollutant removal in constructed wetlands is accomplished by several mechanisms, including sediment trapping, plant uptake, bacterial decomposition, and adsorption. Properly designed and constructed wetlands filter and settle suspended solids. Wetland vegetation used in constructed wetlands converts some pollutants (nitrogen, phosphorus, and metals) into plant biomass (Watson et al., 1988). Nitrification, denitrification, and organic decomposition are bacterial processes that occur in constructed wetlands. Some pollutants, such as phosphorus and most metals, physically attach or adsorb to soil and sediment particles. Therefore, constructed wetlands, used as a management practice, could be an important component in managing NPS pollution from a variety of sources. They are not intended to replace or destroy natural wetland areas, but rather to remove NPS pollution before it enters a stream, natural wetland, or other water body.

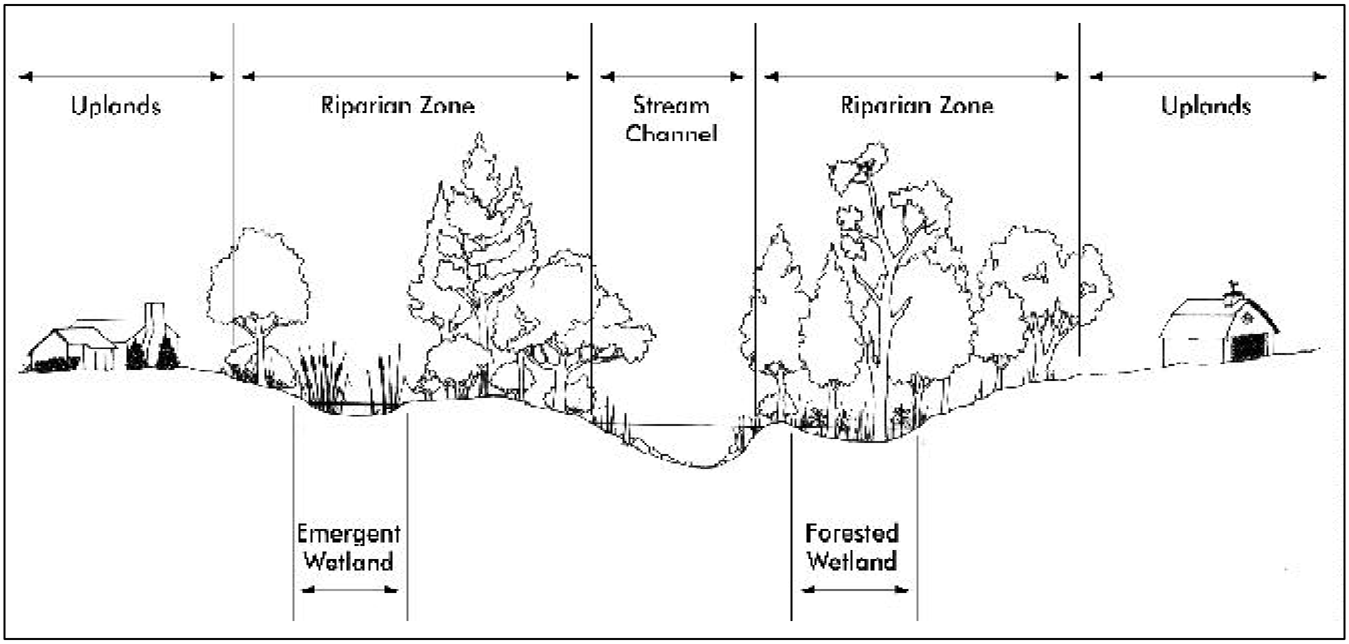

Figure 2-1. Relationship Between Wetlands, Uplands, Riparian Areas, and the Stream Channel